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Proposal No. 57-649E

MINIATURIZED DATA RECORDER
WITH PLAYBACK UNIT

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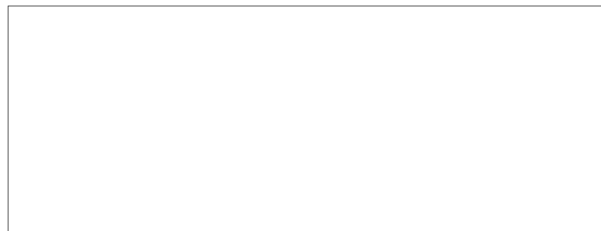
MINIATURIZED DATA RECORDER

WITH PLAYBACK UNIT

Part I

Technical Program

Submitted by

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MINIATURIZED DATA RECORDER
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I INTRODUCTION

This proposal has been prepared at the request of [REDACTED]

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[REDACTED] for submission to the U. S. Government. The program outlined herein covers the electrical engineering aspects of development of a miniaturized data recorder and a playback unit. The development program described is based on the Specification provided, No. 57-A-1059-A, and on discussions between representatives of [REDACTED]

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II REQUIREMENTS

The detailed requirements are given in the Specification and will not be repeated here. The primary requirement is for a highly miniaturized three-channel tape recorder for voice and pulse data recording. Two channels are to be used for data recording while the third is for voice and reference frequency recording. Provisions for monitoring the signal being recorded are required. The recorder must be capable of recording only; a separate non-miniaturized playback unit is to be provided for rewind and data playback.

Primary features of the recorder, in order of priority, are as follows:

1. Size

The complete recorder, including tape, electronic circuits, drive mechanism, and power source, shall be contained in a volume 5" x 3" x 1 1/2".

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2. Frequency Response

The overall response of the system shall be constant within plus or minus 3 db from 250 cps to 10 kc. It is also desired that pulses of 5 microseconds or longer duration be recorded and reproduced as faithfully as possible.

3. Record Time

The recorder should provide a total recording time of 60 minutes on one reel of tape.

It is apparent that these requirements are not mutually compatible and compromises will undoubtedly have to be made. Another difficult requirement in view of space limitations is that of providing a 1000 cps reference signal stable to 1 part in 50,000 over the operating temperature range of minus 30°C to plus 50°C. The remaining operational, environmental, and constructional requirements are achievable from an electrical standpoint and will not be discussed in this proposal. Anticipated problems related to the requirements given above are discussed further in Section III.

III DISCUSSION OF THE PROBLEM

The basic problem is that of recording a maximum amount of information in a minimum space. Thus, the nature of the information required becomes of prime importance. The Specification states that 5 microsecond pulses shall be recorded and reproduced "as faithfully as possible". Thus, it is inferred that detailed information about pulse shape, rise time, width, amplitude, and repetition rate would be desirable. To preserve this information for a 5 microsecond pulse a record and playback system having an upper frequency response of 200 kc to 2 Mc would be required. Considering the 200 kc response as minimum, and assuming a realizable wavelength for tape

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recording, a tape speed near 100 inches per second would result. For 60 minutes recording on tape using 1-mil Mylar backing this would require 30,000 feet of tape occupying a volume of 135 cubic inches. Since this is many times the total allowable volume for the entire recorder, it is obvious that less detailed information can be presented.

An absolute minimum amount of information is that of realizing when pulses have been recorded. If this is refined slightly to recognition of a single pulse, two distinct pieces of information can be obtained; 1) the presence of the pulse, and 2) the repetition rate. In addition, it may be determined if the pulse source is interrupted (either at the source or due to scanning). Large variations in repetition rate would also be recognized. Detailed information such as pulse shape, width, and rise time would be lost. Depending on mode and level of recording, some information relative to pulse amplitude (including amplitude modulation) would be obtained. Thus, a reasonable goal appears to be that of recognizing the presence of a single pulse.

With this in mind, it is now reasonable to consider a more restricted record-playback system. When a short-duration pulse is applied to a record head such that the tape moves only a small fraction of the head gap-width during the pulse time, a segment of tape is recorded the length of which is essentially equal to the head gap-width. In order to record the next pulse the tape must be moved sufficiently to separate the two pulses on the tape (2 gap widths). Under these conditions, the minimum allowable tape speed becomes a function only of the maximum repetition rate being recorded. Each pulse causes a segment to be recorded so long as the repetition rate does not become so high that insufficient space is left between the recorded segments. Essentially, the recording process (in particular, the head gap) performs a

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pulse-stretching function since the recorded pulse length is primarily a function of gap-width rather than primarily a function of pulse time. On playback (same tape speed as record) the recorded pulse will affect the playback head much longer than it took to record the pulse. Thus, the information obtainable from the record will be concentrated more in the lower frequency spectrum. The minimum information of detecting whether a pulse has been recorded and determining repetition rate is available from the fundamental component of the recorded pattern.

In the way of example, a practical system might be:

Maximum repetition rate = 8000 cps (125 microsecond period)

Effective head gap = 0.00025 inches

Tape speed = (8000) (.0005) = 4.0 inches/sec

The required tape volume for this system is 6.4 cubic inches compared to 135 cubic inches for the system providing the more detailed information. More important, it represents only 1200 feet of tape which can be accommodated in a reel of practical dimensions. Since tape is not adaptable to varied packing configurations the length of tape is usually of more concern than volume.

It is presumed that the agency requesting this development program expects the less detailed information, since the upper frequency response of 10 kc specified is compatible with the minimum information obtainable from a system such as that described above.

The discussion and example given above indicates the factors important in the design of the recorder. The recording process should be relatively broad band so that a short duration current pulse is applied to the head. This will cause the recorded segment to be as short as the head gap will allow, rather than being spread out due to inadequate frequency

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response of the record amplifier. The amount of pulse stretching will then be only a function of the head gap. In addition, this will make the recorded amplitude more independent of pulse width and allow interpretation of the signal to derive pulse amplitude and amplitude modulation information. Reduction of the effective head gap to an absolute minimum is the only way to increase the pulse density on the tape. There are other important considerations in the design of the head. Among these are that the pole tips should not saturate on pulse peaks (this would cause spreading of the recorded pulse). Also, to obtain sharp recording the head must be designed for a high self-resonant frequency and of an impedance level such that a constant-current drive is practical.

It should be noted that with high pulse density recording such as proposed here (2000 pulses per inch or higher) pulses will be lost occasionally. This "drop-out" phenomenon is particularly important in digital computer applications. However, it is assumed that in the application of the miniature recorder an occasional missing pulse will not have the serious consequences it has in computer applications.

In addition to minimizing the required volume of tape by using maximum possible pulse density, consideration should be given to decreasing space required by tape take-up. In conventional systems an empty space equal to tape volume must be allowed. This could be reduced by utilizing for take-up the space vacated by the tape as it is recorded. Another technique might consist of rotating the reel of tape without unwinding and have the head essentially thread through the wound reel of tape. Thus, no winding and unwinding occurs and no take-up space is required. Special head designs may be possible which would facilitate mechanical designs of this type.

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Space taken by the batteries can be conserved by designing the circuits for minimum power drain. At the higher temperatures germanium transistors may draw several times the current required for normal operation. Silicon transistors should be considered from this standpoint (the temperatures required are not excessive for germanium transistors). However, silicon transistors do not operate satisfactorily at as low voltages as germanium, and the power required may actually be higher than that for germanium. This matter will be resolved in the early stages of the program.

Another design consideration for space conservation, from the standpoint of number of components required as well as power, is that of type of recording bias to be used. For pulse recording, bias is not essential; however, voice recording requires either a-c or d-c bias. The 15% allowable distortion permits the use of d-c bias. Use of d-c bias would eliminate the bias oscillator circuit, but both voice and pulse recordings would require higher head drive than that required using a-c bias. Again, the choice must be made on the basis of overall space conservation.

The requirement for the stable 1000 cps oscillator is beyond that considered practical using conventional components. However, previous work by [] has resulted in a miniature low-frequency control element which offers great advantages in an application such as this. It is anticipated that [] will supply this element designed for 1000 cps operation for use in the recorder.

The design of the playback unit presents no major difficulties. It is believed that the most efficient and economical approach is to use a commercial transport unit, modified to provide such requirements as variable speed drive. The playback electronics will be specifically designed accord-

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ing to the requirements of the Specification.

IV THE RESEARCH PROGRAM

A. Scope

The work to be carried out by [] covers the electrical engineering aspects of the development program. Specifically, this includes analysis of the electrical requirements and determination of the electrical characteristics, design and construction of the complete playback unit, development of the recorder circuits, head design and construction, and consulting services to [] relative to magnetic recording.

An engineering model of the playback unit will be delivered. Developmental circuits and heads for the recorder will be delivered to [] These circuits will be suitable, by design and choice of components, for inclusion in the engineering model of the recorder. However, the final fabrication of the electronics included in this unit will be performed by []

[] Throughout the program close liaison will be maintained between [] [] to insure compatibility of the mechanical and electrical components. Previous joint efforts between the two organizations have shown that this close coordination is practical and yields excellent results.

The frequency control element for the 1000 cps recorder oscillator will be supplied by [] for incorporation into the circuits designed by [] personnel.

In view of the stringent requirements set forth and the problems they present, the Specification is considered to be a goal rather than an absolute requirement. It is believed that the proposed program will result in a highly miniaturized recorder basically meeting the objectives of the

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procurement, but no guarantee can be given for meeting each specific requirement given in the Specification.

B. Administration

The work outlined in this proposal will be performed on a government sub-contract from [] The sub-contract work will be performed by personnel of [] Electrical Engineering Research Department. Close working relationships between [] and [] personnel will be maintained to insure unity of direction.

Bi-monthly progress reports will be submitted in addition to minutes of each meeting between the two organizations. A final report will be submitted summarizing the development work and describing in detail the equipment developed. This will include all necessary schematics, drawings, and component specifications.

Pertinent experience of [] and specific background of personnel likely to participate in the proposed program are given in the following section. Time and cost estimates are given in Part II of the proposal.

V BACKGROUND AND EXPERIENCE

[] has been active in magnetic recording work for many years, both in basic research and in extending the practical applications. Staff members are continuously engaged in magnetic recording work under [] government, and industrial sponsorship. The scope of work varies from design of special heads to development of complete data recording and processing systems. Recent work has included design and application of the magnetostatic playback heads. The output of the head is proportional to flux rather than rate-of-change of flux. Thus, magnetic records can be read at

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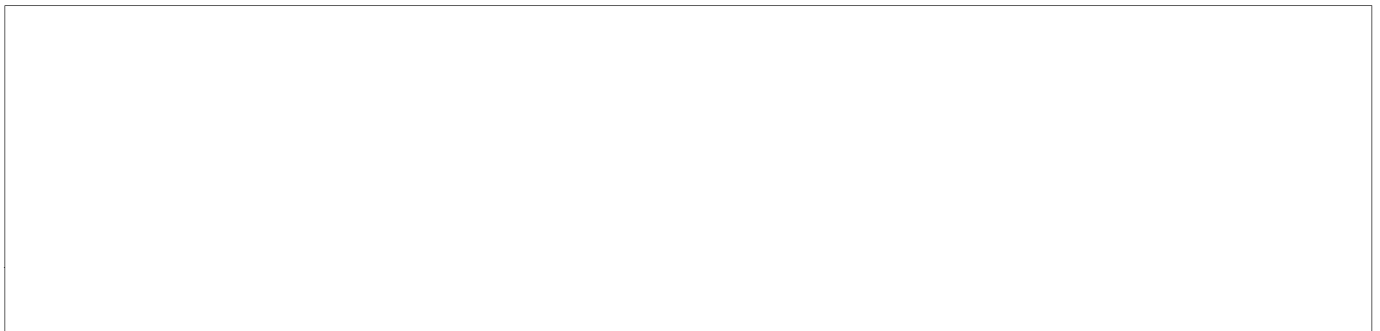
reduced-speed playback, including zero, without loss of amplitude or fidelity.

Staff members have had wide experience in transistor circuit design problems. This experience includes d-c amplifiers, pulse circuits, low-noise amplifiers, control circuits, and many special applications. One specific program was a detailed study of transistor circuits for magnetic recording. Circuits were designed and tested for each record and playback function. Included in the study were record amplifiers, bias and erase oscillators, and playback amplifiers. Consideration was given to head impedance requirements, compensation, and other factors important in obtaining quality reproduction.


The following people are likely to contribute to the proposed program:

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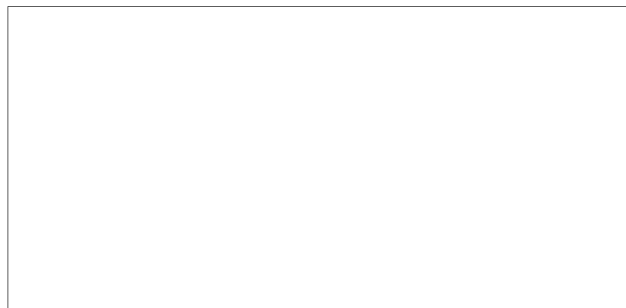
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VI SUMMARY

A program covering the electrical engineering aspects of the development of a miniaturized data recorder with associated playback unit is outlined in this proposal. Many problems must be overcome in order to meet the objectives set forth. It is believed that the combined knowledge and experience of  personnel represents excellent background for effective pursuance of the proposed program.

Respectfully submitted,



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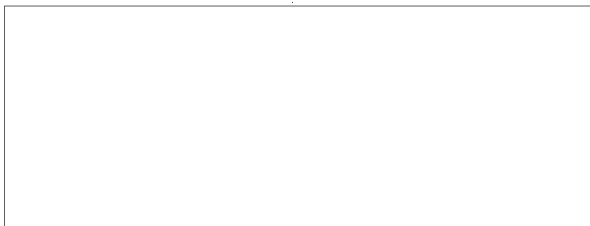
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Part II

Time and Cost Estimate

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It is estimated that the proposed work can be completed within 10 months of initiation of work. The breakdown of estimated cost is as follows:

Salaries:

Engineers	(13 man months at \$700/mo avg.)	\$ 9,100
Technicians	(6 man months at \$500/mo avg.)	3,000
Shop labor	(180 hours at \$3.25/hr avg.)	585
Draftsmen	(160 hours at \$2.75/hr avg.)	440
Total Salaries		<u>\$13,125</u>

Overhead at actual cost, estimated at 86% of salaries	11,287
Purchased materials and components	1,700
Travel and Communications	150
Reproduction of Reports, Drawings, and Schematics	100
Fixed Fee	<u>1,581</u>
Total Cost	<u>\$27,943</u>

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